

**NASA  
Technical  
Memorandum**

NASA TM - 100318

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ARTICLES, PAPERS, AND PRESENTATIONS**

Compiled by Joyce E. Turner  
Management Operations Office

October 1987

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## **FOREWORD**

In accordance with the NASA Space Act of 1958, the MSFC has provided for the widest practicable and appropriate dissemination of information concerning its activities and the results thereof.

Since July 1, 1960, when the George C. Marshall Space Flight Center was organized, the reporting of scientific and engineering information has been considered a prime responsibility of the Center. Our credo has been that "research and development work is valuable, but only if its results can be communicated and made understandable to others."

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GEORGE C. MARSHALL SPACE FLIGHT CENTER  
Marshall Space Flight Center, Alabama

FY 1987 SCIENTIFIC AND TECHNICAL REPORTS,  
ARTICLES, PAPERS, AND PRESENTATIONS

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## NASA TECHNICAL MEMORANDUM

TM-86558 November 1986  
Ground Facility for Large Space Structures  
Dynamics and Control Verification. Henry  
Waites. Systems Dynamics Laboratory.

N87-18600

NASA Marshall Space Flight Center has developed a facility in which closed loop control of Large Space Structures (LSS) can be demonstrated and verified. The main objective of the facility is to verify LSS control system techniques so that on-orbit performance can be ensured. The facility consists of an LSS test article or payload which is connected to a 3-axis angular pointing mount assembly that provides control torque commands. The angular pointing mount assembly is attached to a base excitation system which will simulate disturbances most likely to occur for Orbiter and DOD payloads. The control computer contains the calibration software, the reference systems, the alignment procedures, the telemetry software, and the control algorithms. The total system is suspended in such a fashion that the LSS test article has the characteristics common to all LSS.

TM-86560 November 1986  
5000 GPM Firefighting Module Evaluation Test.  
Ralph Burns. Structures and Propulsion Laboratory.

N87-16919

The 5000 gpm Firefighting Module development was sponsored and shared by the Navy Facilities Engineering Command. It is a lightweight, compact, self-contained, helicopter-transportable unit for fighting harbor and other specialty fires as well as for use in emergency and shipboard water pumping applications. This unit is a more advanced model of the original 1500 GPM module developed for the U.S. Coast Guard.

This report describes the module and an evaluation test program conducted at the North Island Naval Air Station, San Diego, CA, by NASA and the U.S. Navy.

TM-86562 August 1986  
Space Flight Operations Communications  
Phraseology and Techniques. Steven R.  
Noneman. Systems Analysis and Integration  
Laboratory.

N87-12721

Communications are a critical link in space flight

operations. Specific communications phraseology and techniques have been developed to allow rapid and clear transfer of information. Communications will be clear and brief through the use of procedural words and phrases. Communications protocols standardize the required information transferred. The voicing of letters and numbers is discussed. The protocols used in air-to-ground communications are given. A glossary of communications terminology is presented in the appendix.

TM-86563 October 1986  
The Ecology of Microorganisms in a Small  
Closed System: Potential Benefits and Problems  
for Space Station. Elizabeth B. Rodgers.  
Materials and Processes Laboratory.

N87-13166

The inevitable presence on the Space Station of Microorganisms associated with crew members and their environment will have the potential for both benefits and a range of problems including illness and corrosion of materials. This report reviews the literature presenting information about microorganisms pertinent to Environmental Control and Life Support (ECLS) on the Space Station. The perspective of the report is ecological, viewing the Space Station as an ecosystem in which biological relationships are affected by factors such as zero gravity and by closure of a small volume of space.

Potential sites and activities of microorganisms on the Space Station and their environmental limits, microbial standards for the Space Station, monitoring and control methods, effects of space factors on microorganisms, and extraterrestrial contamination are discussed.

TM-86564 September 1986  
Theory of Ostwald Ripening in a Two-  
Component System – Center Director's Discre-  
tionary Fund Final Report. James K. Baird, Li  
Kao Lee, Donald O. Frazier, and Robert J.  
Naumann. Space Science Laboratory.

N87-13497

When a two-component system is cooled below the minimum temperature for its stability, it separates into two or more immiscible phases. The initial nucleation produces grains (if solid) or droplets (if liquid) of

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one of the phases dispersed in the other. The dynamics by which these nuclei proceed toward equilibrium is called Ostwald ripening. We shall assume that the nuclei are spheres, thereby treating the case of droplets rigorously and the case of grains approximately.

The dynamics of growth of the droplets depends upon the following factors: (1) The solubility of the droplet depends upon its radius and the interfacial energy between it and the surrounding (continuous) phase. The equation governing this phenomenon is associated with the names of Gibbs and Kelvin, and we derive it for the case of two components. There is a critical radius determined by the supersaturation in the continuous phase. Droplets with radii smaller than critical dissolve, while droplets with radii larger grow. (2) The droplets concentrate one component and reject the other. The rate at which this occurs is assumed to be determined by the interdiffusion of the two components in the continuous phase. Associated with this diffusion is advection, which is accounted for in our theory to lowest order in the center of volume velocity of the two components. Moreover, when the droplets occupy a finite fraction of the total volume of the system, there occur effects of inter-droplet competition on the concentration field in the continuous phase. This increases the overall rate of growth of the droplet phase. Using diagrammatic techniques and rigorous statistical mechanics, we show that this effect depends upon the square root of the volume fraction associated with the grains, and that it accelerates both the rate of growth and the rate of dissolution of droplets. (3) The Ostwald ripening is constrained by conservation of mass; e.g., the amount of material in the droplet phase plus the remaining supersaturation in the continuous phase must equal the supersaturation available at the start. (4) There is a distribution of droplet sizes associated with a mean droplet radius, which grows continuously with time. This distribution function satisfies a continuity equation, which we solve asymptotically by a similarity transformation method.

The final results of our theoretical analysis consist of the following quantities determined as functions of time: (1) the supersaturation remaining in the continuous phase, (2) the total number of droplets in the continuous phase, (3) the distribution of droplet sizes, (4) the critical droplet radius, (5) the mean droplet radius, and (6) the maximum droplet radius. Each of

these is also determined as a function of the volume fraction occupied by the droplets. We apply these results to the system, succinonitrile/water, which separates into two immiscible liquid phases below its consolute temperature at 58°C. This system is particularly attractive because it is transparent to visible light, so the rate of formation of the droplet phase can be followed photographically. In general, the droplet phase has a different density than the continuous phase. Separation of the two by sedimentation competes with the process of Ostwald ripening. In the acceleration-free environment of an Earth orbiting laboratory, the Ostwald ripening in the system succinonitrile/water should be observable without interference by sedimentation or any other effects associated with gravitation. We provide a complete set of specifications for the design of such an experiment.

TM-86565

August 1986

The Multispectral Atmospheric Mapping Sensor (MAMS): Instrument Description, Calibration, and Data Quality. Gary J. Jedlovec, W. Paul Menzel, Robert Atkinson, Gregory S. Wilson, and John Arvesen. Systems Dynamics Laboratory. N87-12828

A new instrument has been developed to produce high resolution imagery in eight visible and three infrared spectral bands from an aircraft platform. An analysis of the data and calibration procedures has shown that useful data can be obtained at up to 50 m resolution with a 2.5 milliradian aperture. Single sample standard errors for the measurements are 0.5, 0.2, and 0.9°K for the 6.5, 11.1, and 12.3  $\mu\text{m}$  spectral bands, respectively. These errors are halved when a 5.0 milliradian aperture is used to obtain 100 m resolution data. Intercomparisons with VAS and AVHRR measurements show good relative calibration. MAMS development is part of a larger program to develop multispectral Earth imaging capabilities from space platforms during the 1990s.

TM-86566

October 1986

Development of Low-Temperature Transistor Modules to Improve the MSFC Mid-Infrared Array - Center Director's Discretionary Fund Final Report. C. M. Telesco, R. Decher, and P. Peters. Space Science Laboratory. N87-12756

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This report describes the low-temperature transistor modules designed for use with the MSFC mid-infrared array. The modules were developed in the Space Science Laboratory at Marshall Space Flight Center with Center Director's Discretionary Funds. The transistors (JFETs), which operate at a temperature of 77 K, are epoxied to a copper surface attached to a Teflon substrate. The module substrate insulates the JFETs from the 1.5K detector work surfaces and provides a convenient mounting structure for additional components such as solder pins. These modules have maintained their structural integrity during repeated temperature cycling, and they have proven to be convenient during maintenance and servicing of the infrared array.

[illegible]

Slow strain-rate tests were conducted on 2024 aluminum alloy at various aging conditions to determine stress corrosion susceptibility. The strain rate that produces the best results for this alloy is in the range of  $1.5 \times 10^{-6}$  to  $2.0 \times 10^{-6}$  in./in./s. This test program revealed that the elongation at fracture and the fracture energy were the best test parameters for evaluating stress corrosion susceptibility of this alloy in 3.5% NaCl solution. The slow strain-rate testing gave similar results to alternate immersion testing, but both methods had some scatter in the data. The slow strain-rate test method, which can give quicker results than the alternate immersion method, can be used as a screening test for assessing stress corrosion susceptibility of aluminum alloys in salt solutions.

[illegible]

Al-In-Sn alloys have been directionally solidified in the NASA KC-135 aircraft which flies a series of

parabolas to generate high (high-g) and low gravity (low-g) forces parallel to the longitudinal growth axis. Thus, for a given sample, successive sections can be identified which were solidified in high-g and low-g. Measurements of the electronic properties of the samples reveal that: (1) the resistivity of the low-g sections is larger (about a factor of 10) than that of the high-g sections; (2) the low-g sections behave conductively like a semi-metal, while the high-g sections are essentially metallic; and (3) both high-g and low-g sections are superconducting but the superconducting transition temperature of the low-g sections is 1 K higher than that of the high-g sections.

TM-86570 October 1986  
Experimental Evaluation of the Ring Focus Test  
for X-Ray Telescopes Using AXAF's Tech-  
nology Mirror Assembly, MSFC CDDF Final  
Report, Project No. H20. D. E. Zissa and D.  
Korsch. Information and Electronic Systems  
Laboratory. N87-15916

A test method particularly suited for x-ray telescopes was evaluated experimentally. The method makes use of a focused ring formed by an annular aperture when using a point source at a finite distance. This would supplement measurements of the best focus image which is blurred when the test source is at a finite distance. The telescope used was the Technology Mirror Assembly of the AXAF program. Observed ring image defects could be related to the azimuthal location of their sources in the telescope even though in this case the predicted sharp ring was obscured by scattering, finite source size, and residual figure errors.

TM-86571    September 1986  
Solid Rocket Motor Integrity Program, First  
Progress Report, October 1, 1984 Through  
March 31, 1986. Richard L. Brown and Richard  
M. Sanders. Special Projects Office.  
X87-10064

The Solid Rocket Motor (SRM) Integrity Program was begun in the fall of 1984 by the National Aeronautics and Space Administration (NASA) in response to concerns expressed in Congress, NASA, Department of Defense (DOD), and industry about the frequency of the SRM failures and anomalies experi-

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enced during 1983 and early 1984. An industry wide assessment in the spring of 1984 indicated a number of technological shortfalls in the ability to design, manufacture, and verify the integrity of SRM nozzles. This program was specifically undertaken to improve the engineering technology base for SRM nozzles. The program involves nine major tasks in the areas of constituent materials and process characterization, design analysis, material properties data bases, process variables, process science, product evaluation (including NDE), thermal and structural code development, instrumentation, and verification/validation testing. Many of the weaknesses in the engineering technology base addressed in the program were recognized at the outset, but the work to date has shown that they are more serious than originally thought. Materials properties data bases used for design are inconsistent and incomplete. Process variability and control are not well understood. Thermostructural computer codes are used mainly to assess nozzles which have been designed by experience, engineering judgment, and empirical formula, rather than using them as a primary design tool. Further, the codes have not been verified with SRM firings, and no test derived failure criteria is available. Test data on nozzle thermostructural behavior is limited and has wide discrepancies due to improper strain gauge and thermocouple selection, calibration, attachment, and adhesive selection and application. The program is scheduled to continue through fiscal year 1988. This paper presents the background, structure and status/results of the work through March 1986.

TM-86572    October 1986  
Solid Rocket Motor Integrity Program, Summary  
Progress Report, October 1, 1984 Through June  
30, 1986. Richard L. Brown. Special Projects  
Office.    X87-10063

The Solid Rocket Motor (SRM) Integrity Program was begun in the fall of 1984 by the National Aeronautics and Space Administration (NASA) in response to concerns expressed in Congress, NASA, Department of Defense (DOD), and industry about the frequency of the SRM failures and anomalies experienced during 1983 and early 1984. An industry wide assessment in the spring of 1984 indicated a number of technological shortfalls in the ability to design, manufacture, and verify the integrity of SRM nozzles.

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TM-86573 November 1986  
The Effects of Gravity Level During Directional  
Solidification on the Microstructure of Hyper-  
monotectic Al-In-Sn Alloys. P. A. Curreri and  
W. F. Kaukler. Space Science Laboratory.  
N87-16901

Five hypermonotectic Al-In-Sn compositions were directionally solidified in a Bridgman-type furnace at normal gravity and during aircraft low-gravity maneuvers. The tendency of the Al-30In alloy to form an indium-rich band at the start of unidirectional growth (SUG) made it difficult to study the integration of  $L_2$  into the solidification interface. Hypermonotectic compositions closer to monotectic "slightly hypermonotectic" caused only a partial band of  $L_2$  to form at SUG and allowed the study of such variables as gravity, composition, and monotectic dome height on integration of excess  $L_2$  into the solid plus  $L_1$ .



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interface. It was found that formation of aligned composite structures for the Al-In-Sn system is not only a function of G and R but also of the degree to which the composition varies from on monotectic. Most of the aligned fibrous structures formed from hypermonotectic Al-In-Sn had spacings that were of the order of irregular fibrous structures reported for on monotectic Al-In-Sn. The spacings for the large fibers and aligned globules found for ground and low-gravity processed Al-18In-22Sn, respectively, were significantly larger than the others measured and were of the order expected for cell spacings under the growth conditions utilized. It was found that the integration into the solidification front of excess  $L_2$  in low gravity was a function of the Sn composition of the alloy.

TM-86574 December 1986  
Small Computer Interface to a Stepper Motor.  
Fred A. Berry, Jr. Space Science Laboratory.  
N87-16970

A Commodore VIC-20 computer has been interfaced with a stepper motor to provide an inexpensive stepper motor controller. Only eight transistors and two integrated circuits compose the interface. The software controls the parallel interface of the computer and provides the four phase drive signals for the motor. Optical sensors control the zeroing of the 12-inch turntable positioned by the controller. The computer calculates the position information and movement of the table and may be programmed in BASIC to execute automatic sequences.

TM-86575 October 1986  
FY 1986 Scientific and Technical Reports, Articles, Papers, and Presentations. Compiled by Joyce E. Turner. Management Operations Office.  
N87-17532

This document presents formal NASA technical reports, papers published in technical journals, and presentations by MSFC personnel in FY 86. It also includes papers of MSFC contractors.

After being announced in STAR, all the NASA series reports may be obtained from the National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161.

The information in this report may be of value to the scientific and engineering community in determining what information has been published and what is available.

TM-86576 December 1986  
Space Shuttle Main Engine Vibration Data Base.  
Pat Lewallen. Systems Dynamics Laboratory.  
N87-16876

This memorandum describes the Space Shuttle Main Engine Vibration Data Base. It includes a detailed description of the data base components, the data acquisition process, the more sophisticated software routines, and the future data acquisition methods. Several figures and plots are provided to illustrate the various output formats accessible to the user. This document reveals the numerous vibration data recall and analysis capabilities available through automated data base techniques.

TM-86577 December 1986  
Atmospheric Environment for Space Shuttle (STS-51L) Launch. G. L. Jasper, D. L. Johnson, M. Alexander, G. H. Fichtl, and G. W. Batts. Systems Dynamics Laboratory. N87-18950

This report presents a summary of selected atmospheric conditions observed near Space Shuttle STS-51L launch time on January 28, 1986, at Kennedy Space Center Florida. Values of ambient pressure, temperature, moisture, ground winds, visual observations (cloud), and winds aloft are included. The sequence of pre-launch Jimsphere measured vertical wind profiles is given in this report. The final atmospheric tape, which consists of wind and thermodynamic parameters versus altitude, for STS-51L vehicle ascent has been constructed. The STS-51L ascent atmospheric data tape has been constructed by Marshall Space Flight Center's Atmospheric Sciences Division to provide an internally consistent data set for use in post flight performance assessments.

TM-86578 December 1986  
Non-Metallic Materials Sample Array. H. M. King, D. D. Webb, and B. E. Goldberg. Materials and Processes Laboratory.  
N87-16910

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The Non-Metallic Materials Sample Array (MSA) was flown as verification flight instrumentation (VFI) on both Spacelab 1 (SL-1) and Spacelab 2 (SL-2). The basis for materials selection was either previous flight history or probable flight suitability based upon analysis.

The observed changes in the optical properties of the exposed materials are, in general, quite minimal; however, this data represents the short exposure of two Space Shuttle missions, and no attempt should be made to extrapolate the long-term exposure.

The MSA was in orbit for 10 days at approximately 240 km on SL-1 and for 7 days at approximately 315 km on SL-2. The array was exposed to the solar flux for only a portion of the time in orbit.

TM-86579 December 1986  
On the Analytical Determination of Relaxation Modulus of Viscoelastic Materials by Prony's Interpolation Method. Pedro I. Rodriguez. Structures and Propulsion Laboratory. N87-17455

A computer implementation to Prony's curve fitting by exponential functions is presented. The method, although more than one hundred years old, has not been utilized to its fullest capabilities due to the restriction that the time range must be given in equal increments in order to obtain the best curve fit for a given set of data.

The procedure used in this paper utilizes the 3-dimensional capabilities of the Interactive Graphics Design System (I.G.D.S.) in order to obtain the equal time increments. The resultant information is then input into a computer program that solves directly for the exponential constants that yield the best curve fit. Once the exponential constants are known, a simple least squares solution can be applied to obtain the final form of the equation.

TM-86580 January 1987  
Solid Rocket Booster Joint Seal Analyses. Dr. Carleton J. Moore. Structures and Dynamics Laboratory. N87-17039

This report documents O-ring response and sealing in pressurized shell structures. The study found

that the key elements in the failure of the seal to be joint opening and rotation, assembly out of roundness, and O-ring seal response.

TM-86581 January 1987  
Interface Circuitry for Superconducting Bolometer. P. J. Nelson. Space Science Laboratory. N87-17016

The interface circuitry described in this report links the computer with the superconducting bolometer array. This helps demonstrate the feasibility of the array. Using the circuitry and the array, imaging will be made possible. Initial imaging will be done on laboratory objects, and the pixel characteristics will be investigated experimentally.

TM-86582 December 1986  
SRB O-Ring Free Response Analysis. Dr. Carleton J. Moore. Structures and Dynamics Laboratory. N87-17040

This report investigates the free response of viton O-rings. Two different response mechanisms of viton O-rings are identified and a theoretical representation of the two mechanisms is compared with experimental results for various temperatures.

TM-86583 January 1987  
An Experimental Study of Laser-Supported Plasmas for Laser Propulsion - Final Report - Center Director's Discretionary Fund Project DFP-82-33. R. H. Eskridge, T. D. McCay, and D. M. Van Zandt. Propulsion Laboratory. N87-24985

The rudiments of a rocket thruster, which receives its enthalpy from an energy source which is remotely beamed from a laser, is described. An experimental study, now partially complete, is discussed which will eventually provide a detailed understanding of the physics for assessing the feasibility of using hydrogen plasmas for accepting and converting this energy to enthalpy. A plasma ignition scheme which uses a pulsed CO<sub>2</sub> laser has been developed and the properties of the ignition spark documented, including breakdown intensities in hydrogen. A complete diagnostic system capable of determining plasma temperature and the plasma absorptivity for subsequent steady-state

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absorption of a high power CO<sub>2</sub> laser beam are developed and demonstrative use is discussed for the preliminary case study, a two atmosphere laser supported argon plasma.

TM-86584 January 1987  
Statistical Analysis of 59 Inspected SSME HPFTP Turbine Blades (Uncracked and Cracked). John T. Wheeler. Structures and Dynamics Laboratory. N87-16877

This technical memorandum presents the numerical results of statistical analysis of the test data of Space Shuttle Main Engine high pressure fuel turbo-pump second-stage turbine blades, including some with cracks. Several statistical methods use the test data to determine the application of differences in frequency variations between the uncracked and cracked blades.

TM-86585 December 1986  
Low-G Measurements by NASA. Roger P. Chassay and Arthur J. Schwaniger, Jr. Structures and Dynamics Laboratory. N87-17017

NASA has utilized low-g accelerometers on a variety of flights for over 12 years. These flights have included aircraft parabolas, suborbital trajectories, and orbital missions. This large quantity of data has undergone only limited in-depth analyses. Examples of data in many forms and results of analyses such as power spectral densities and shock spectra are given for a wide variety of missions. Accelerometers used to acquire the data are also identified.

TM-86586 January 1987  
Evaluation of the Sealing Capabilities of Several O-ring Materials in Subscale, Cold-gas Pressurization Tests. James E. Turner. Materials and Processes Laboratory. X87-10203

The object of this test effort was to evaluate the sealing capabilities of several different O-ring materials in a subscale, cold-gas fixture. The focus of interest was on the ability of the tested O-rings to effectively seal a gap that was opening while pressure was being applied to the seal. The effect of temperature, particularly sub-ambient conditions, on the ability of the O-rings to effectively seal was a major considera-

tion. All O-rings tested at ambient conditions (70 to 80°F) were able to effectively seal the prescribed gap openings. Decreasing the test temperature correspondingly decreased the sealing ability of some of the tested material.

TM-86587 March 1987  
Ignition Overpressure Study from Solid Rocket Motor Firings. Douglas D. Counter. Structures and Dynamic Laboratory. N87-18607

The objective of this study was to investigate, through experimental means, the basic mechanisms influencing ignition overpressure and to determine ways to suppress ignition overpressure. Ignition overpressure was studied using solid rocket motors with geometry scaled at 1 percent of the Shuttle's Solid Rocket Boosters. Both water injection and aerosol foam were examined as a means of reducing ignition overpressure. The results of the water injection tests indicate that a relatively small amount of water is sufficient to provide significant suppression. Of the flow rates tested, the lower water injection flow rates provided the best reduction of the ignition overpressure wave. Also, the test results show there is an optimum water flow rate range that provides the best suppression, and as this range is exceeded the effectiveness of water to reduce ignition overpressure is decreased. Aerosol foam provided very little reduction of ignition overpressure, but only small volumes of foam were used and further testing is necessary to determine its total effectiveness as a means of suppression.

TM-86588 March 1987  
Equations of Motion of a Space Station with Emphasis on The Effects of the Gravity Gradient. L. P. Tuell. Structures and Dynamics Laboratory. N87-21993

The derivation of the equations of motion is based upon the principle of virtual work. As developed, these equations apply only to a space vehicle whose physical model consists of a rigid central carrier supporting several flexible appendages (not interconnected), smaller rigid bodies, and point masses. Clearly evident in the equations is the respect paid to the influence of the Earth's gravity field, considerably more than has been the custom in simulating vehicle motion. The effect of unpredictable crew motion is ignored.

## NASA TECHNICAL MEMORANDUM

TM-86589 February 1987  
Meeting Report – Yosemite Conference on  
Ionospheric Plasma in the Magnetosphere:  
Sources, Mechanisms, and Consequences. D. L.  
Gallagher, J. L. Burch, D. M. Klumpar, T. E.  
Moore, and J. H. Waite, Jr. Space Science  
Laboratory. N87-20689

The sixth biennial Yosemite topical conference and the first as a Chapman Conference was held on February 3 to 6, 1986. Due to the recent changes in our perception of the dynamics of the ionospheric/magnetospheric system, it was deemed timely to bring researchers together to discuss and contrast the relative importance of solar versus terrestrial sources of magnetospheric plasma. Although the solar wind was once thought to dominate the supply of plasma in the Earth's magnetosphere, it is now thought that the Earth's ionosphere is a significant contributor. Polar wind and other large volume outflows of plasma have been seen at relatively high altitudes over the polar cap and are now being correlated with outflows found in the magnetotail. The auroral ion fountain and cleft ion fountain are examples of ionospheric sources of plasma in the magnetosphere, observed by the Dynamics Explorer 1 (DE 1) spacecraft.

The conference was organized into six sessions: four consisting of prepared oral presentations, one poster session, and one session for open forum discussion. The first three oral sessions dealt separately with the three major topics of the conference, i.e., the sources, mechanisms, and consequences of ionospheric plasma in the magnetosphere. A special session of invited oral presentations was held to discuss extraterrestrial ionospheric/magnetospheric plasma processes. The poster session was extended over two evenings during which presenters discussed their papers on a one-on-one basis. The last session of the conference was reserved for open discussions of those topics or ideas that were the most interesting or controversial.

TM-86590 March 1987  
Rapid Melt/Quench Furnace Using Commercially Available Hardware. Richard M. Poorman.  
Spacelab Payload Project Office. N87-20431

This report describes an off-the-shelf Orbital Tube Welder that can be easily used to melt and resolidify most any electrically conductive material. This can be done on a KC-135 Aircraft within the microgravity period of one parabola. Melt sizes 3 mm diameter by 10 mm length and larger are feasible with most if not all materials. A highly reproducible, controlled, programmable heat and cool cycle can be provided. Sample measurements would have to be developed and could be as sophisticated or as simple as desired. These could include: optical and thermocouple temperature measurements, Peltier pulser for marking the solidification fronts, dimensional changes and whatever. Sample heat flows could be fixed over a very wide range being limited mostly by the cooling period, the desired sample size, and the 20 sec microgravity period of the KC-135 Aircraft parabola.

TM-86591 March 1987  
Celestial Target Observability for Astro Spacelab Missions. Larry D. Mullins. Systems Analysis and Integration Laboratory. N87-22696

This report presents the mathematical technique for calculating the amount of time that an astronomical object, e.g., a star, can be observed from a satellite in a near Earth orbit. This includes the places and times in the orbit where the object is acquired and where it is lost. Constraints placed on the observation of the object, such as the line-of-sight from observer to target must not come within less than some specified angle to the limb of the Earth, are included in the calculations.

The equations developed within the report are then used for a detailed analysis of the observation possibilities for objects at any place on the celestial sphere for a typical Spacelab ASTRO mission. The results, presented in graphic form, are suitable for use in pre-mission planning and also for use in real-time replanning.

TM-86593 April 1987  
Automatic Detection of Electric Power Troubles (AI Application). Caroline Wang, Hugh Zeanah, Audie Anderson, and Clint Patrick. Information and Electronics Systems Laboratory. N87-23893

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The design goals for the Automatic Detection of Electric Power Troubles (ADEPT) were to enhance Fault Diagnosis Techniques in a very efficient way. ADEPT system was designed in two modes of operation: (1) real Time Fault Isolation and (2) a local simulator which simulates the models theoretically.

TM-86594 March 1987  
Characterization and Hardware Modification of Linear Momentum Exchange Devices. George D. Edgemon, Sally Curtis, and Henry B. Waites. Structures and Dynamics Laboratory.  
N87-24723

A sequence of modifications were made on the TRW Linear Momentum Exchange Devices (LMEDs) which were supplied for a joint MSFC/Air Force Wright Aeronautical Laboratory (AFWAL) control venture called Vibrational Control of Space Structures (VCOSS)-II. The modifications were necessary to alleviate and assuage the LMED nonlinearities. Extensive discussion of the LMED modifications are presented along with the test plan, test results and conclusions. In addition, a chronology of events, relative to the LMED changes, is contained in the paper.

TM-86595 April 1987  
A Preliminary Mechanical Property and Stress Corrosion Evaluation of VIM-VAR Work Strengthened and Direct Aged Inconel 718 Bar Material. J. W. Montano. Materials and Processes Laboratory.  
N87-26216

This report presents a preliminary mechanical property and stress corrosion evaluation of double melted [vacuum induction melted (VIM), and vacuum arc remelted (VAR)], solution treated, work strengthened and direct aged Inconel 718 alloy bar [5.50 in. (13.97 cm) diameter] processed by Wyman Gordon.

Two sets of tensile specimens, one direct single aged and the other direct double aged, were tested at ambient temperature in both the longitudinal and transverse directions. Longitudinal tensile and yield strengths in excess of 200 ksi (1378.96 MPa) and 168 ksi (1158.22 MPa) respectively, were realized at ambient temperature, for the direct double aged specimens.

No failures occurred in the single or double aged longitudinal and transverse tensile specimens stressed to 75 and 100 percent of their respective yield strengths and exposed to a salt fog environment for 180 days. Tensile tests performed after the stress corrosion test indicated no mechanical property degradation.

TM-100306 June 1987  
Large Space Structures Testing. Dr. Henry Waites and Dr. H. Eugene Worley. Structures and Dynamics Laboratory.  
N87-24520

There is considerable interest in the development of testing concepts and facilities that accurately simulate the "pathologies" believed to exist in future spacecraft. Both the Government and Industry have participated in the development of facilities over the past several years. The purpose of this paper is to present the progress and problems associated with the development of the Large Space Structure Test Facility at the Marshall Space Flight Center. This facility has been in existence for a number of years and its utilization has run the gamut from total in-house involvement, third party contractor testing, to the mutual participation of other Government Agencies in joint endeavors.

TM-100307 June 1987  
Shuttle Coherent Atmospheric Lidar Experiment (SCALE). J. Bilbro, R. Beranek, D. Fitzjarrald, and J. Mabry.  
N87-23959

This document contains the results of a study to design and accommodate a simplified version of a Coherent Lidar System which is capable of performing tropospheric wind measurements from orbit. The document contains data on: system sensitivity, orbital analysis, science experiments, preliminary system design, accommodations, and a detailed look at the Space qualification of a 2J. CO<sub>2</sub> laser.

TM-100308 June 1987  
Distributed Control Using Linear Momentum Exchange Devices. J. P. Sharkey, Henry Waites, and G. B. Doane III. Structures and Dynamics Laboratory.  
N87-24521

MSFC has successfully employed the use of the Vibrational Control of Space Structures (VCOSS) Linear Momentum Exchange Devices (LMEDs),

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which was an outgrowth of the Air Force Wright Aeronautical Laboratory (AFWAL) program, in a distributed control experiment. The control experiment was conducted in MSFC's Ground Facility for Large Space Structures Control Verification (GF/LSSCV). The GF/LSSCV's test article was well suited for this experiment in that the LMED could be judiciously placed on the ASTROMAST. The LMED placements were such that vibrational mode information could be extracted from the accelerometers on the LMED. The LMED accelerometer information was processed by the control algorithms so that the LMED masses could be accelerated to produce forces which would dampen the vibrational modes of interest. Experimental results are presented showing the LMED's capabilities.

TM-100309 June 1987  
Component Response to Random Vibratory  
Motion of the Carrier Vehicle. L. P. Tuell. Struc-  
tures and Dynamics Laboratory. N87-26396

Two physical models of component plus supporting substructure are considered. Each model consists of a rigid body attached to a moving base by means of linear springs and viscous dampers. The second model differs from the first in that its dampers are elastically supported. The first model receives the more extensive treatment. Base motion, assumed a random translational motion parallel to a fixed axis, is prescribed only to the extent that the power spectral density (PSD) of its acceleration is given; and, as given, its plot on log-log graph paper is a series of straight line segments, each segment having an extremity in common with the adjacent segment. Closed expressions are given for the mean squares of base acceleration, base velocity, and base displacement. The component is restricted to planar motion and allowed two degrees of freedom, one translational and one rotational. Integral expressions are given for the mean squares of component response variables, the transfer functions essential to mean square computation being available via the equations of motion. Closed expressions are given for mean squares of certain of the response variables for the case wherein the base acceleration PSD is constant. A very brief paragraph is given to stability of motion.

tionary Fund Final Report. C. A. Meegan, W. F. Fountain, and F. A. Berry, Jr. Space Science Laboratory.

This report describes a system to rapidly digitize data from showers in nuclear emulsions. A TV camera views the emulsions through a microscope. The TV output is superimposed on the monitor of a minicomputer. The operator uses the computer's graphics capability to mark the positions of particle tracks. The coordinates of each track are stored on disk. The computer then predicts the coordinates of each track through successive layers of emulsion. The operator, guided by the predictions, thus tracks and stores the development of the shower. The system provides a significant improvement over purely manual methods of recording shower development in nuclear emulsion stacks.

TM-100311 August 1987  
Program Risk Analysis Handbook. R. G. Batson.  
Program Development.

Several NASA regulations specify that formal risk analysis be performed on a program at each of several milestones as it moves toward full-scale development. Program risk analysis is discussed as a systems analysis approach to risk, an iterative process (identification, assessment, management), and a collection of techniques. These techniques, which range from extremely simple to complex network-based simulation, are described in this handbook in order to provide both analyst and manager with a guidebook for selection of the most appropriate technique.

All program risk assessment techniques are shown to be based on elicitation and encoding of subjective probability estimates from the various area experts on a program. Techniques to encode the five most common distribution types are given. Then, a total of twelve distinct approaches to risk assessment are given. Steps involved, good and bad points, time involved, and degree of computer support needed are listed.

Why risk analysis should be used by all NASA program managers is discussed. How to establish a risk analysis capability and some of the special difficulties

TM-100310 August 1987  
A computer System to Analyze Showers in  
Nuclear Emulsions – Center Director's Discre-

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in performing a risk analysis are related. Tools available at NASA-MSFC are identified, along with commercially available software. Both an extensive bibliography (150 entries) and a program risk analysis check-list are provided.

TM-100312 September 1987  
1987 Progress Report of Manufacturing Techniques for Gravity Probe B Gyroscope Rotors. Roy A. Taylor, Ed White, and William J. Reed. Materials and Processes Laboratory.

This report presents the significant improvements in the manufacture of Gravity Probe B gyroscope rotors that have been developed since the publication of the last report on this project. The improvements discussed include the polishing machine structure, rough laps, finishing/polishing laps, lapping procedure, measurement techniques, and a summary of the manufacturing status. These six areas represent significant improvements in manufacturing of the gyroscope rotors which will meet flight requirements.

TM- September 1987  
Analysis of the Bivariate Parameter Wind Differences Between Jimsphere and Windsonde. Michael Susko. Structures and Dynamics Laboratory.

The purpose of this report is to present an analysis of the bivariate parameter differences between the FPS-16 Radar/Jimsphere and the Meteorological Sounding System (MSS) Windsonde. The Jimsphere is used as the standard to measure the ascent wind loads during the Space Shuttle launches at Kennedy Space Center, Florida, and the Windsonde is the backup system. In addition, in the report a discussion of the terrestrial environment (below 20 km) and a description of the Jimsphere and Windsonde wind sensors are given. Computation of the wind statistics from 64 paired Jimsphere and Windsonde balloon releases in support of 14 Space Shuttle launches shows good agreement between the two wind sensors.

The computed difference values in m/s of the mean zonal wind ( $\bar{u}$ ) and mean meridional wind ( $\bar{v}$ ) of the Jimsphere and Windsonde at 500 m intervals from the surface to 16 km shows good agreement between the wind components. The ( $\bar{u}$ ) and ( $\bar{v}$ ) mean dif-

ferences for the 64 paired observations were 0.16 and 0.22 m/s respectively, while the standard deviations of the mean differences of  $\bar{u}$  and  $\bar{v}$  were 1.38 and 1.73 m/s, respectively.

From the analysis of the buildup and back-off data for various scales of distance and the comparison of the cumulative percent frequency (CPF) versus wind speed change, it is shown that the wind speed change for various scales of distances (m) 100, 200, 400, 600, 800, 1000, 2000, 3000, and 5000 for the Jimsphere and Windsonde compare favorably. For example, the average altitude, where the greatest buildup occurred for all the scales of distances was at 10,427 m for the Jimsphere, 10,529 m for the Windsonde, and 10,474 m for the Jimsphere/Windsonde pairs, a range of only 102 m. The S.D. of these parameters was 2999, 3029, and 3007 m, less than a 50 m difference.

The variance difference of energy for the Power Spectral Density parameters for the u and v components of the Jimsphere and Windsonde was less than  $\pm 0.02 \text{ m}^2/\text{sec}^2$ . This showed very good agreement between the Jimsphere Wind sensor and its backup, the Windsonde in the all-important variance parameter, the energy difference between the Jimsphere and Windsonde at various wavenumbers or wavelengths.

TM-4006 August 1987  
Space/COHMEX Data Inventory Document. S. F. Williams, H. M. Goodman, K. R. Knupp, and J. E. Arnold. Structures and Dynamics Laboratory.

During the period June through July 1987, NASA conducted the Satellite Precipitation and Cloud Experiment (SPACE) in the central Tennessee, northern Alabama, and northeastern Mississippi area. In addition to SPACE, the Microburst and Severe Thunderstorm (MIST) Program, sponsored by the National Science Foundation, and the FAA-Lincoln Laboratory Operational Weather Study (FLOWS), sponsored by the Federal Aviation Administration, operated concurrently under the acronym COHMEX (COoperative Huntsville Meteorological EXperiment). The COHMEX field program incorporated measurements from remote sensors flown on high altitude aircraft (ER-2 and U-2), Doppler and conventional radars,

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rawinsondes, satellites, cloud physics research aircraft, and various surface observational systems.

This document contains a brief description of the field program and a daily data collection summary. Chapter 2 summarizes the program instrumentation and facilities, and includes sample selected data

products. Chapter 3 provides a meteorological summary, operations overview, and an inventory of the data collected for each day of the field program. The purpose of this document is to provide the researcher and scientist with a tool to select data sets for case studies and instrument evaluation.



## NASA TECHNICAL PAPERS

TP-2671 December 1986  
Microgravity Crystallization of Macromolecules:  
An Interim Report and Proposal for Continued  
Research. Benjamin E. Goldberg. Materials and  
Processes Laboratory. N87-20423

An initial investigation exploring the effects of gravity on the crystallization of macromolecular systems has been completed. Monodisperse poly(ethylene), molecular weight 48,000 was melted and recrystallized under three gravitational conditions: 0, 1, and 2 g. No correlations to gravitational environment were noted for the 20°C/min melt, as monitored with a photodensitometer system. However, post-crystallization testing of the recrystallized samples revealed thicker samples with more regions of large, well defined spherulites for the zero gravity crystallization environment.

The results of the post-crystallization analysis have been reviewed and the results related to nucleation concerns. Finally, birefringence data, consistent with, but not explained by, the nucleation scenarios is detailed, and further investigations are proposed.

TP-2685 January 1987  
Space Shuttle Main Engine High Pressure Fuel  
Pump Aft Platform Seal Cavity Flow Analysis.  
S. A. Lowry and L. W. Keeton. Structures and  
Propulsion Laboratory. N87-17000

A general purpose, three-dimensional computational fluid dynamics code named PHOENICS, developed by CHAM Inc., is used to model the flow in the aft-platform seal cavity in the high pressure fuel pump of the space shuttle main engine. The model is used to predict the temperatures, velocities, and pressures in the cavity for six different sets of boundary conditions. The results are presented as input for further analysis of two known problems in the region, specifically: erratic pressures and temperatures in the adjacent coolant liner cavity and cracks in the blade shanks near the outer diameter of the aft-platform seal.

TP-2690 February 1987  
Solar Array Flight Experiment/Dynamic  
Augmentation Experiment. Leighton E. Young,  
and Homer C. Pack, Jr. Information and  
Electronic Systems Laboratory and Systems  
Dynamics Laboratory. N87-20380

This report presents the objectives, design testing, and data analyses of the Solar Array Flight Experiment/Dynamic Augmentation Experiment (SAFE/DAE) that was tested aboard Shuttle in September 1984. The SAFE was a lightweight, flat-fold solar array that employed a thin polyimide film (Kapton) as a substrate for the solar cells. Extension/retraction, dynamics, electrical and thermal tests, were performed. Of particular interest is the dynamic behavior of such a large lightweight structure in space. Three techniques for measuring and analyzing this behavior were employed. The methodology for performing these tests, gathering data, and data analyses are presented.

The report shows that the SAFE solar array technology is ready for application and that new methods are available to assess the dynamics of large structures in space.

TP-2697 February 1987  
Dynamic Characteristics of a Vibrating Beam  
with Periodic Variation in Bending Stiffness.  
John S. Townsend. Structures and Dynamics  
Laboratory.

A detailed dynamic analysis is performed of a vibrating beam with bending stiffness periodic in the spatial coordinate. Using a perturbation expansion technique the effects of system parameters on beam response are explored. It is found that periodic stiffness acts to modulate the modal displacements from the characteristic shape of a simple sine wave. The results are verified by a finite element solution and through experimental testing.

TP-2710 March 1987  
Space Station Structures and Dynamics Test  
Program. Carleton J. Moore, John S. Townsend,  
and Edward W. Ivey. Structures and Dynamics  
Laboratory. N87-20568

The design, construction, and operation of a low-Earth orbit Space Station poses unique challenges for development and implementation of new technology. The technology arises from the special requirement that the station be built and constructed to function in a weightless environment, where static loads are minimal and secondary to system dynamics and control problems. One specific challenge confronting

NASA is the development of a dynamics test program for (1) defining Space Station design requirements, and (2) identifying and characterizing phenomena affecting the station's design and development. A general definition of the Space Station dynamic test program, as proposed by MSFC, forms the subject of this report.

The test proposal, as outlined herein, is a comprehensive structural dynamics program to be launched in support of the Space Station. The test program will help to define the key issues and/or problems inherent to large space structure analysis, design, and testing. Development of a parametric data base and verification of the math models and analytical analysis tools necessary for engineering support of the station's design, construction, and operation provide the impetus for the dynamics test program. The philosophy being to integrate dynamics into the design phase through extensive ground testing and analytical ground simulations of generic systems, prototype elements, and subassemblies. On-orbit testing of the station will also be used to define its capability.

TP-2714 April 1987  
Statistical Aspects of Solar Flares. Robert M. Wilson. Space Science Laboratory.  
N87-20947

A survey of the statistical properties of 850 H $\alpha$  solar flares during 1975 is presented. Comparison of the results found here with those reported elsewhere for different epochs is accomplished. Distributions of rise time, decay time, and duration are given, as are the mean, mode, median, and 90th percentile values. Proportions by selected groupings are also determined. For flares in general, mean values for rise time, decay time, and duration are  $5.2 \pm 0.4$  min,  $12.9 \pm 0.8$  min, and  $18.1 \pm 1.1$  min, respectively. Subflares, accounting for nearly 90 percent of the flares, had mean values lower than those found for flares of H $\alpha$  importance  $\geq 1$ , and the differences are statistically significant. Likewise, flares of "bright" and "normal" relative brightness have mean values of decay time and duration that are significantly longer than those computed for "faint" flares, and mass-motion related flares are significantly longer than non-mass-motion related flares. Seventy-three percent of the mass-motion related flares are categorized as being a two-ribbon flare

and/or being accompanied by a high-speed dark filament. Slow rise time flares (rise time  $> 5$  min) have a mean value for duration that is significantly longer than that computed for fast rise time flares, and long-lived duration flares (duration  $> 18$  min) have a mean value for rise time that is significantly longer than that computed for short-lived duration flares, suggesting a positive linear relationship between rise time and duration for flares. Indeed, such is the case. Monthly occurrence rates for flares in general and by group are found to be linearly related in a positive sense to monthly sunspot number; as sunspot number increased (decreased), number of flares increased (decreased). Statistical testing reveals the association between sunspot number and numbers of flares to be significant at the 95 percent level of confidence, and the t statistic for slope is significant at  $> 99$  percent level of confidence. Dependent upon the specific fit, between 58 percent and 94 percent of the variation can be accounted for with the linear fits. A statistically significant northern hemisphere flare excess ( $P < 1$  percent) was found, as was a western hemispheric excess ( $P \approx 3$  percent). Subflares were more prolific within 45 deg of central meridian ( $P < 1$  percent), while flares of H $\alpha$  importance  $\geq 1$  were more prolific near the limbs ( $> 45$  deg from central meridian;  $P \approx 2$  percent). Two-ribbon flares were more frequent within 45 deg of central meridian ( $P < 1$  percent). Slow rise time flares occurred more frequently in the western hemisphere ( $P \approx 2$  percent), as did short-lived duration flares ( $P \approx 9$  percent), but fast rise time flares were not preferentially distributed (in terms of east-west or limb-disk). Long-lived duration flares occurred more often within 45 deg of central meridian ( $P \approx 7$  percent). Mean durations for subflares and flares of H $\alpha$  importance  $\geq 1$ , found within 45 deg of central meridian, are 14 percent and 70 percent, respectively, longer than those found for flares closer to the limb. As compared to flares occurring near cycle maximum, the flares of 1975 (near solar minimum) have mean values of rise time, decay time, and duration that are significantly shorter. A flare near solar maximum, on average, is about 1.6 times longer than one occurring near solar minimum.

TP-2715 April 1987  
The Corrosion Mechanisms for Primer Coated 2219-T87 Aluminum. Merlin D. Danford and Ward W. Knockemus. Materials and Processes Laboratory.  
N87-21076

In an effort to investigate metal surface corrosion and the breakdown of metal protective coatings, the AC Impedance Method was applied to zinc chromate primer coated 2219-T87 aluminum. The EG&G-PARC Model 368 AC Impedance Measurement System, along with DC measurements with the same system using the Polarization Resistance Method, was used to monitor changing properties of coated aluminum disks immersed in 3.5 percent NaCl solutions buffered at pH 5.5 and pH 8.2 over periods of 40 days each.

The corrosion system can be represented by an electronic analog called an equivalent circuit that consists of resistors and capacitors in specific arrangements. This equivalent circuit parallels the impedance behavior of the corrosion system during a frequency scan. Values for resistances and capacitances, that can be assigned in the equivalent circuit following a least squares analysis of the data, describe changes that occur on the corroding metal surface and in the protective coatings.

A suitable equivalent circuit has been determined that predicts the correct Bode phase and magnitude for the experimental sample. DC corrosion current density data are related to equivalent circuit element parameters.

TP-2724 April 1987  
Liquid Drop Stability for Protein Crystal Growth in Microgravity. Robert B. Owen, Beth H. Broom, Robert S. Snyder, and Ron Daniel. Space Science Laboratory. N87-20727

It is possible to grow protein crystals for biomedical research in microgravity by deploying a protein-rich solution from a syringe, forming a drop in which crystallization can occur with the proper degree of supersaturation. Drop stability is critical to the success of this research, due to the large drop sizes which can be achieved in space. In order to determine the type of syringe tips most suitable to support these large drops, tests were performed during brief periods of weightlessness onboard the NASA KC-135 low-gravity simulation aircraft. The drops were analyzed using three simple computer models in which the samples were approximated by modified pendulum and spring systems. It was concluded that the higher frequency

systems were the most stable, indicating that of the syringes utilized, a disk-shaped configuration provided the most stable environment for low-gravity protein crystal growth.

TP-2732 June 1987  
Modeling Digital Control Systems With MA-Filtered Measurements. Michael E. Polites. Structures and Dynamics Laboratory. N87-22870

This paper derives three discrete state variable representations for a continuous-time plant driven by a zero-order-hold with a combination of instantaneous measurements and measurements prefiltered by moving-average (MA) digital filters. These representations allow the control system engineer to accurately model plants of this type in a form which permits him to use standard techniques to design digital feedback controllers for them. An example is presented which illustrates how to obtain the coefficient matrices in each representation. Guidelines are presented for choosing the best representation to use for any given plant of this type.

TP-2744 July 1987  
Hydrogen Trapping and the Interaction of Hydrogen with Metals. Merlin D. Danford. Materials and Processes Laboratory. N87-25463

A method has been developed for the determination of trapped hydrogen in metal alloys. It involves the determination of mobile hydrogen using the electrochemical method and the determination of total hydrogen with the fusion method, the difference in hydrogen concentrations being due to trapped hydrogen.

It has been found that hydrogen enters body-centered cubic structures primarily through the grain bodies rather than through the grain boundaries. Hydrogen also diffuses much more rapidly in body-centered cubic structures on charging than in face-centered cubic structures, the hydrogen distribution being more uniform in nature. The energy necessary to cause hydrogen embrittlement is postulated to arise from the changes in crystal lattice energies brought about through interaction of hydrogen with atoms in

the metal lattice. The total energy change is more negative for body-centered cubic structures, believed to be the cause of a greater tendency toward hydrogen embrittlement. Finally, the agreement of hydrogen concentrations obtained at 25°C by the electrochemical method with those obtained by the fusion method are taken as a strong indication of the power and validity of the electrochemical method.

TP-2745 July 1987  
A New Approach to State Estimation in Deterministic Digital Control Systems. Michael E. Polites. Structures and Dynamics Laboratory. N87-24585

This paper presents a new approach to state estimation in deterministic digital control systems. The scheme is based on sampling the output of the plant at a high rate and prefiltering the discrete measurements in a multi-input/multi-output moving average (MA) process. The coefficient matrices in the MA prefilter are selected so the estimated state equals the true state. An example is presented which illustrates the procedure to follow to completely design the estimator.

TP-2757 August 1987  
Exact State Reconstruction in Deterministic Digital Control Systems. Michael E. Polites. Structures and Dynamics Laboratory.

This report presents a new state reconstructor for deterministic digital control systems which is ideal in the following sense: if the plant parameters are known exactly, the output of the new state reconstructor will exactly equal the true state of the plant, not just approximate it. Furthermore, this ideal state reconstructor adds no additional states or eigenvalues to the system. Nor does it affect the plant equation for the system in any way; it affects only the measurement equation. While there are countless ways of choosing the ideal state reconstructor parameters, two distinct methods are described here. An example is presented which illustrates the procedures to completely design the ideal state reconstructor using both methods.

TP-2759 August 1987  
Probabilistic Risk Analysis of Flying the Space Shuttle With and Without Fuel Turbine Discharge Temperature Redline Protection. Leonard Howell. Structures and Dynamics Laboratory.

The paper presents an exact mathematical model of the Space Shuttle Main Engine computer voting logic in the presence of High Pressure Fuel Turbine (HPFT) overtemperature events and fuel turbine temperature sensor failures. The model provides estimates of the probability of erroneous engine shutdown and the probability of not detecting a HPFT overtemperature event.

Because it is believed that the likelihood of sensor failures and overtemperature events in the HPFT greatly overshadows those in the High Pressure Oxygen Turbine (HPOT), this modeling effort has been focused on the HPFT. However, because the redline protection logic is the same for both turbines, estimation of the model parameters using relevant HPOT data would provide estimates of the risk of erroneous engine shutdown and an undetected overtemperature event occurring in the HPOT.

Because of the complexity of the model, it was necessary to program the solution which thus makes it feasible to accommodate a changing data base. This is considered to be of great interest because of the subjective nature in determining the relevancy of certain failures and the fact that the data base is constantly changing as a result of the frequent engine tests.

TP- September 1987  
Continuous Flow Electrophoresis System Experiments on Shuttle flights STS-6 and STS-7. Robert S. Snyder, Percy H. Rhodes, and Teresa Y. Miller. Space Science Laboratory.

In 1978, McDonnell Douglas Astronautics Company (MDAC) began discussions with NASA on the opportunities to develop a space continuous flow electrophoresis system (CFES) that would incorporate specific modifications to their laboratory instruments to take advantage of weightlessness. A Joint Endeavor Agreement (JEA) that allocated certain flights on the Space Shuttle to MDAC in return for opportunities for NASA and interested scientists to do research in the MDAC laboratory and on their space instruments was made.

Under terms of the JEA, NASA was provided an opportunity to process two samples on STS-6. All experiment objectives and operational parameters,

such as applied field, sample residence time in the field, and buffer composition had to accommodate the MDAC capabilities and NASA flight constraints. The NASA objectives were formulated so as to include investigation of the sample concentration effects reported by MDAC on STS-4. The specific objectives were (1) to use a model sample material at a high concentration to evaluate the continuous flow electrophoresis process in the MDAC CFES instrument and compare its separation resolution and sample throughput with related devices on Earth and (2) to expand our basic knowledge of the limitations imposed by fluid flows and particle concentration effects on the electrophoresis process by careful design and evaluation of the space experiment. Because the MDAC instrumentation did not include sample mixing facilities, cell separation procedures were precluded and after a variety of soluble materials were considered, hemoglobin and polysaccharide were selected as primary samples. The results from space show a large band spread of the high concentration of the single species of hemoglobin that was principally due to the mismatch of electrical conductivity between the sample and buffer.

The seventh mission of the Space Shuttle carried two additional NASA experiments in the CFES instrument. The major objective was to evaluate the influence of the electrical properties of the sample constituents on the resolution of the continuous flow electrophoresis device. As expected, the polystyrene latex microspheres dispersed in a solution with three times the electrical conductivity of the curtain buffer separated with a significantly larger band spread than in the second experiment under matched conductivity conditions. The structure of the bands is also different between the samples and laboratory experiments have been conducted to further evaluate the phenomena affecting the electrophoresis. The analysis of both flight results is nearing completion and a qualitative explanation based upon the non-gravity dependent electrical conductivity mismatch is being developed.

TP- September 1987  
Preparative Electrophoresis for Space. Percy H. Rhodes and Robert S. Snyder. Space Science Laboratory.

A basic premise of continuous flow electrophore-

sis is that removal of buoyancy-induced thermal convection caused by axial and lateral temperature gradients will result in ideal performance of these instruments in space. Although these gravity dependent phenomena disturb the rectilinear flow in the separation chamber when high voltage gradients and/or thick chambers are used, distortion of the injected sample stream due to electrohydrodynamic effects causes major broadening of the separated bands.

Although the electrophoresis separation process is simple in concept, flows local to the sample filament produced by the applied electric field have not been considered. These electrohydrodynamic flows, formulated by G. I. Taylor in 1965 for drops suspended in various liquids, distort the sample stream and limit the separation. In addition, electroosmosis and viscous flow, which are inherent in the continuous flow electrophoresis device, combine to further disturb the process. Electroosmosis causes a flow in the chamber cross section which directly distorts the sample stream, while viscous flow causes a parabolic profile to develop in the flow plane. This flow profile in turn distorts migration by causing a varying residence time across the thickness of the chamber. Thus, sample constituents in the center plane will be in the electric field a shorter time and hence move less than comparable constituents closer to the chamber wall.

A moving wall concept is being proposed for space which will eliminate and/or control all of the above-mentioned disturbances. The moving wall will entrain the fluid to move as a rigid body and hence produce a constant residence time for all samples distributed across the chamber thickness. By aligning the moving wall at an angle to the chamber axis, a component of the moving wall motion can be made to oppose and hence cancel the electroosmotic flow. In the absence of electrokinetic effects, i.e., electroosmosis, the electrohydrodynamical effect manifests itself as a ribbon, being either vertical (perpendicular to the electric field) or horizontal (aligned with the electric field) depending on the ratio of conductivity of the sample to that of the buffer. Therefore, by using low conductivity sample solutions to provide a vertical ribbon, the moving wall concept should produce distortion-free separations.

The moving wall electrophoresis chamber can only be operated in space because there is no viscous

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flow in the chamber to stabilize against thermal convection. Laboratory prototype instruments have been built which confirm the sensitivity of their operation. These prototypes have also identified engineering problems such as liquid seals. However, the moving

wall electrophoresis system is a concept designed for space which should permit preparative electrophoresis to attain its potential.

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- CP-2467, Part 1 April 1987  
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Flexible Structures. Edited by Robert S. Ryan  
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- CP-2467, Part 2 April 1987  
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- CP-2469 May 1987  
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N87-23313

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(Abstracts for these reports may be obtained from STAR)

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| CR-178927   | May 19, 1986       | CR-178936  | September 1986     |
| Thermophotovoltaic Space Power System, Quarterly Status Report February 6-May 6, 1986. NAS8-33436. Boeing Aerospace Co. X86-90307   |                    | Selected Tether Applications in Space Volume 2, Phase 3 Final Report. NAS8-36616. Martin Marietta. N87-18593   |                    |
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| <p>DeSANCTISS, CARMINE E. PS02<br/>           PRIEST, C. C.<br/>           WOOD, W. V.<br/>           Space Station Overview. For presentation and publication at the AIAA 25th Aerospace Sciences Meeting, Reno, Nevada, January 12-15, 1987.</p>   | <p>DHINDAW, B. K. ES74<br/>           STEFANESCU, D. M.<br/>           CURRERI, P. A.<br/>           BANDYOPADHYAY, D. K.<br/>           Solidification of Carbide-Metal Matrix Composites of the Fe-VC Type Under Variable Gravity Levels. For presentation at the Solidification Processing, 1987 Conference, Sheffield, England, September 21-24, 1987.</p> |
| <p>DECKER, RAND (NRC)ED42<br/>           A Constitutive Relationship for the Particulate Stresses and Interphase Interaction Terms for Non-Dilute Two Phase Fluid/Solid Flows. For presentation at the AIAA Aerospace Sciences Meeting, Reno Nevada, January 11-14, 1988.</p>                | <p>DILL, CHARLIE ED35<br/>           COX, GEORGE B., JR. Pratt &amp; Whitney<br/>           SSME Hot Gas Manifold Flow Comparison Tests. For presentation at the AIAA 26th Aero Space Science Meeting Fluid Dynamics, Reno, NV, January 11-14, 1988.</p>   |
| <p>DELCOURT, D. C. ES51<br/>           CHAPPELL, C. R.<br/>           IMF Dependence of Ionospheric Ion Transport in the Magnetosphere. For presentation at the AGU Fall Meeting, San Francisco, CA, December 6-11, 1987.</p>  | <p>DING, Y. J. ES52<br/>           HAGYARD, M. J.<br/>           DeLOACH, A. C., et al.<br/>           Explorations of Electric Current System in Solar Active Regions. For publication in Solar Physics, The Netherlands.</p>   |
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| <p>DENT, WILLIAM R. F. ES65<br/>           Infrared Radiative Transfer in Dense Discs Around Young Stars. For publication in Astrophysical Journal, Chicago, IL.</p>   | <p>DUNCAN, REYNOLDS KA51<br/>           Out of This World Logistics. For presentation at</p>   |

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- EBISUZAKI, TOSHIKAZU ES65  
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- EBISUZAKI, TOSHIKAZU ES65  
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| <p>FOUNTAIN, JAMES A.<br/>Commercial Materials Processing in Space. For presentation on the 17th Symposium on Economics in Space Operations, 38th IAF Congress, Brighton, UK, October 9-17, 1987.</p>  | <p>PS05</p> | <p>Waves and Instabilities in Mag. and at Comets. Sendai/ Mt. Zao, Japan, October 12-16, 1987.</p>  |
| <p>FOWLIS, W. W.<br/>KORNFELD, D. M.<br/>ROBERTS, G. O.<br/>The Rotary Reactor – A Method for Achieving Microgravity in an Earthbound Laboratory. For presentation at the Fortieth Ann. Mtg. Amer. Physical Society Division of Fluid Mechanics, Eugene, OR, November 22-24, 1987.</p>                         | <p>ES76</p> | <p>GALLAGHER, D. L.<br/>CRAVEN, P. D.<br/>GURNETT, D. A.<br/>A New Empirical Model of Density in the Earth's Inner Magnetosphere. For presentation at the 1987 Spring AGU, Baltimore, MD, May 18-22, 1987.</p>  |
| <p>FOWLIS, W.<br/>ROBERTS, G.<br/>DRAKE, M.<br/>RADCLIFFE, M.<br/>Determination of the Flow in the 3M Company's Space Crystal Growth Experiments. For publication in the Journal of Crystal Growth, The Netherlands.</p>   | <p>ES76</p> | <p>GARY, GILMER A.<br/>Solar Magnetic Fields Research. For presentation at the Mechanical Engineering Department, University of Alabama in Huntsville, May 15, 1987.</p>  |
| <p>FRAZIER, DONALDO.<br/>Spectroscopic Analysis to Characterize Miscibility-Gap Type Homogeneous Solution Gradients Near a Crystal Surface. For presentation at the 39th Pittsburgh Conference &amp; Exposition on Analytical Chemistry &amp; Applied Spectroscopy, New Orleans, LA, February 22-26, 1988.</p> | <p>ES75</p> | <p>GARY, GILMER A.<br/>NEERGAARD, JOHN R.<br/>The Salingaros Paradox of Force-Free Magnetic Fields. For publication in the Journal of Physics, England.</p>   |
| <p>FREEMAN, MICHAEL S.<br/>The Emergence of Multi-User Expert Systems. For presentation at the Conference on Artificial Intelligence for Space Applications, Huntsville, AL, November 13-14, 1986.</p>   | <p>EL66</p> | <p>GERNERT, K.<br/>SMITH, R.<br/>CARTER, D.<br/>A Simple Apparatus for Controlling Nucleation and Size in Protein Crystal Growth. For publication in the Journal of Analytical Biochemistry, San Francisco, CA.</p>                                   |
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| <p>GALLAGHER, D. L.<br/>ASHOUR-ABDALLA, M.<br/>Plasma Wave Modes in Multi-Ion Plasmas. For presentation at Chapman Conference on Plasma</p>  | <p>ES01</p> | <p>GIUDICI, ROBERT J.<br/>Block II Mars In-Situ Resource Processing. For presentation at the Case for Mars III, Boulder, CO, July 18-22, 1987.</p>  |
|  |             | <p>GOODMAN, H. M.<br/>KARITANI, S.<br/>PARKER, K. G.<br/>STOOKSBURY, L. M.<br/>WILSON, G. S.</p>  |

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- GREENE, MICHAEL UAH  
CARTER, THERON  
RUPP, CHARLES G. PS04  
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- GREGORY, J. C. ES63  
EDGELL, M. J.  
PETERS, P. N.  
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- HACHISU, IZUMI ES65  
MIYAJI, SHIGEKI  
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- HAGYARD, M. J. ES52  
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- HAGYARD, M. J. ES52  
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- HARRIS, RONALD J. PD01  
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- HARRISON, JAMES K. PS04  
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		WAITE, J. H., JR.	
		The Precipitation of Energetic Heavy Ions into the Upper Atmosphere of Jupiter. For publication in the Journal of Geophysical Research, Washington, D.C.	
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		BRACE, L. H.	ES51
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		CHANDLER, M. O.	
HILL, H.	JA53	COMFORT, R. H.	
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		Polar O <sup>+</sup> Beams. For presentation at the IAGA Division II Symposium, Vancouver, Canada, August 9-22, 1987.	
HINMAN, ELAINE M.	EB24	HORWITZ, J. L.	ES53
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HODGES, BOBBY	AH01	HUBER, WILLIAM G.	FA71
HOUSTON, CHARLES	AH01	Orbital Maneuvering Vehicle: A New Capability. For presentation at the "Thirty Years Progress in Space" IAF Thirty-eighth Congress, Brighton, UK, October 9-17, 1987.	
BAILEY, ROBERT	BCSS		
ROBINS, PHIL	BCSS	HUNG, R. J.	ED42
Design and Strategy for Distributed Data Processing. For presentation at the Third International Conference on Data Engineering, Los Angeles, CA, February 2, 1987.		TSAO, Y. D.	
HOFMEISTER, W. H.	ES74	HONG, B. B.	
ROBINSON, M. B.		LESLIE, FRED W.	
BAYUZICK, R. J.		Dynamical Behavior of Surface Tension on Rotating Fluids in Low Gravity. For presentation at the AIAA 26th Aerospace Sciences Meeting, Reno, NV, January 10-14, 1988.	
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HAHN, E.	Allied Corp.	LESLIE, FRED W.	
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| STONE, N. H., et al.   |            |  |
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| IRBY, THOMAS M., JR.   | PF20       |  |
| National Transportation Studies. For presentation to the SAE Aerospace Technology Conference and Exposition, Long Beach, CA, October 13-16, 1986.  |            |  |
| JAAP, JOHN   | EL22       |  |
| DAVIS, ELIZABETH   |            |  |
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| JENNINGS, J. L.  | TRW        |  |
| WRIGHT, J.   | TRW        |  |
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|   |                            | HUETER, U.   |
|   |                            | BROWN, N. PD22   |
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| STONE, N. H.  |                            |  |
| WRIGHT, K. H., JR.  |                            |  |
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| BHATT, P.   |      |   |
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| CRAVENS, T. E.   |      | PARNELL, T. A.   |       |
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| WAITE, J. H.   | ES53 |  |       |
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| PETERSON, W. K.  |      |  |       |
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| WALLS, JUSTIN  | PS04 | WILSON, G. S.  | ED41  |
| GREENE, MICHAEL  |      | BUTLER, D.   |       |
| RUPP, CHARLES C.   |      | Earth Science and the Space Station. For presentation at the 25th AIAA Aerospace Sciences Meeting, Reno, NV, January 12-14, 1987.  |       |
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| WATTERS, H. H.   | FA71 | WILSON, ROBERT M.  | ES52  |
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CHU, C. W.  
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GARY, ALLEN  
SMITH, J. F.

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YOUNG, ARCHIE C. PD32  
Mars Mission Profile Options and Opportunities. For presentation at the Case for Mars III Strategies for Exploration, Boulder, Colorado, July 18-22, 1987.

## APPROVAL

### FY 1987 SCIENTIFIC AND TECHNICAL REPORTS, ARTICLES, PAPERS, AND PRESENTATIONS

Compiled by Joyce E. Turner

The information in this report has been reviewed for technical content. Review of any information concerning Department of Defense or Atomic Energy Commission programs has been made by the MSFC Security Classification Officer. This report, in its entirety, has been determined to be unclassified.

*for R. W. Phillips*  
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C. D. BEAN  
Director, Administrative Operations Office